The Effects of New Urban Rail Transit: Evidence from Five Cities

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Abstract

Many U.S. cities invest in large public transit projects in order to reduce private vehicle dependence and to reverse the downward trend in public transit use. Using a unique panel data set for five major cities that upgraded their transit systems in the 1980s, we estimate new transit's impact on usage and housing values, using distance as a proxy for transit access. New rail transit has a small impact on usage and housing values. This impact is enough to represent tangible benefits of new transit to nearby residents. High transit subsidization from non-local sources explains the continued push to build new rail transit lines. New transit's benefits are not uniformly distributed. We document which demographic groups are over represented in transit growth areas and the changes in transit usage by different demographic groups.

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I. Introduction

Public transit use has been declining for decades. Between 1940 and 1990, the number of trips made using public transit in the United States fell from over 13 billion to under 9 billion, as the population more than doubled (O'Sullivan 1996).

In tandem with this decline in transit usage, private vehicle usage has continued to rise. Between 1975 and 1990, the civilian population grew by 15.9% while total vehicle miles traveled in passenger cars grew by 43.6% (Downs 1992). Commuting by private vehicle continues to grow in popularity due to growing household incomes, suburbanization of population and employment, rising quality of private vehicles and the declining price of gasoline.

While urban public transit usage is down, more cities are investing in improving and building new rail transit systems.[1] During the 1980s, light rail became a popular transit option because it is cheaper to build and maintain than heavy rail (commonly known as subways or commuter rail) yet is potentially as clean and comfortable.

Increased supply in the face of falling demand may appear puzzling. While such transit projects are costly, much of the cost is borne by the federal government. The local share of operating expenses range from 15% to 50% for most major transit systems (National Urban Mass Transit Statistics 1989). The local share of capital improvement expenses was an average of 20% in 1989 (APTA

[1]For a comprehensive recent review of the literature on the costs and benefits of public transport projects see Mackertt and Edwards (1998).

http://www.apta.com/stats/fundcap/capfund.htm).[2]

Transit authorities are optimistic that there are large potential gains from building new transit. If the introduction of improved public transit reduces private vehicle use, local air pollution would be lower, there would be less vehicle congestion, and the transportation sector would make a smaller contribution toward Greenhouse gases.[3] While local air quality has improved sharply over the last 25 years due to Clean Air Act regulations, congestion is a growing urban problem (Downs 1992).[4] In addition, better transit may disproportionately improve the quality of life and the quality of job opportunities for the urban poor.[5] Public transit also increases the access of the poor to better labor market opportunities (Kain 1968).[6]

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[2]In San Diego, the system cost per rider of light-rail transit is 2.7 times the cost of the bus system that it complements (Gomez-Ibañez 1985). Los Angeles is expected to spend $5.9 billion, or $300 million per mile for its new Red Line subway. Portland has spent approximately $40 million per mile to build its surface light rail line. Denver, Dallas, Baltimore, St. Louis and San Diego have all spent between $10 and $40 million per mile for their light rail systems, depending on the need for land seizure by eminent domain, tunneling, single/double tracking, and the extent to which the rail line is grade separated from roadways (Richmond 1998).

[3]For a discussion of the costs of congestion in large cities see Downs (1992) and Glaeser (1998). For an analysis of the costs of air pollution from motor vehicles see Small and Kazimi (1995).

[4]If public transit improvements lead to commuter mode substitution, then congestion might fall. Alternatively, “new peak period motorists soon take the place of those who switch to transit (Small and Gomez-Ibañez 1999).”

[5]In 1990, households in poverty who lived in central cities had a 19.7% lower probability of owning a vehicle relative observationally identical households in poverty who live in the same metropolitan area’s suburbs (Glaeser, Kahn, and Rappaport 1998).

[6]As jobs have moved to the suburbs, mass transit has increasingly served reverse-commuters, mostly poor people who live in the center city and work in low-skilled jobs in the suburbs (Ihlandfeldt & Sioquist 1989).

Transportation upgrades represent a sizable component of local public infrastructure investment. Researchers have questioned the cost/benefit modeling which lies behind the decision to push forward with costly irreversible transit projects. There is evidence that ex-ante overly optimistic forecasts of usage and cost are common (Gomez-Ibáñez 1985, 1996 Kain 1990, 1997, Pickrell 1992).

A necessary condition for increased transit to have citywide benefits is that it give incentives to commuters to switch travel modes. This paper uses a unique panel data set to study whether there is increased public transit usage in geographical areas whose distance to rail transit has decreased due to transit expansion. Transit upgrades may change household commuting patterns if they significantly reduce the time cost of commuting by public modes. A cost minimizing household will switch modes if the full cost of public transit use becomes less than that of private commuting as a result of better rail access.

Our empirical work also addresses the question of which demographic groups gain the most from rail improvements. New transit is spatially concentrated in certain areas. Given that minorities and the poor are more heavily concentrated in central cities, different demographic groups will be affected differently by transit upgrades. We also explore how rental and home prices are affected by transit. Transit projects represent a local land improvement. Given that the federal government pays a majority of the costs, it is interesting to study who benefits. Evidence of capitalization effects are important for judging how this place based transfer has affected different parts of metropolitan areas.

We study how new transit affects usage, which demographic groups gain, and its real estate capitalization effects by examining "before" and "after" data for census tracts in five cities which upgraded rail transit between 1980 and 1990. This study's unique empirical contribution is to use geographical mapping software to establish for each census tract within a 25 kilometer radius of each central business district its distance (measured in kilometers) from the nearest rail transit line in 1980 and 1990. As new transit is built between 1980 and 1990, a tract's distance from transit changes, affecting ridership and housing values.

We exploit the variation in transit access changes among census tracts within five cities to evaluate the effects of transit expansions. Extending transit lines makes public transit more accessible and reduces the time cost of commuting by public transit. This tract level variation in proximity to public transit allows us to estimate richer econometric models than can be estimated using aggregate city level annual data. Our study complements aggregate transport studies which explain year to year variation in city transit ridership using macro variables such as annual average income growth and changes in gas prices.

To preview this paper's findings, rail transit improvements lead to increased mass transit use for commutation. While some of the 1980 to 1990 increase in public transit use in tracts which experienced access improvements is caused by the new migrants to these tracts having higher probabilities of using public transit than tract incumbents, we estimate that the transit improvements lead to a small amount of mode switching toward public transit among residents who did not migrate between 1980 and 1990. Because the majority of transit improvements studied here go into the suburbs, we find that the greatest beneficiaries have been non-blacks and people over age 35. In addition, we find that proximity to rail transit is capitalized into home prices and rents.

II. Transit Upgrades in Five Metropolitan Areas

Five U.S. cities were chosen for the analysis. Boston, Atlanta, Chicago, Portland, and Washington D.C. were the only five large American metropolitan areas with discrete rail transit improvements during the 1980s.[7] The use of five cities for analysis allows us to generalize results beyond just one metropolitan area to better make a judgement on the effects of transit expansions in general.[8] The five case cities also happen to represent various regions of the country and types of transit networks. Boston and Chicago represent old cities with networks that have continually operated for over 80 years and are currently in the process of renewal and expansion. Because of their highly centralized and relatively dense structure, these two cities may be among the best candidates for viable mass transit. Atlanta and Washington have new comprehensive heavy rail systems which had not existed in these cities since the late 1940s. Despite the lack of rail transit until the

[7]New transit lines or segments in these cities opened between the end of 1979 and 1988. There was no incremental opening of tract segments during the census taking period in 1979 or 1989, thus there is no question that the "treatment" of adding new transit access occurred between the two censuses, with ample time to allow individuals to alter their commuting behavior before being evaluated by the 1990 census.

[8]Though several other cities expanded their transit networks during the 1980s as well, notably Los Angeles, San Diego and Baltimore, their expansions were sufficiently incremental such that it is hard to evaluate for the purposes of analysis where one decade ended and the next began.

1970s, both of these cities had relatively high transit usage when compared to the average U.S. metropolitan area. Finally, Portland's light rail line represents the newly popular incremental approach to the establishment of a rail transit network.[9]

Table One presents some facts on how much access increased in each city between 1980 and 1990.[10] In 1980 the average tract for the 5 city sample was 4.76 kilometers from transit. In 1990, the average tract from the same set was 3.11 kilometers away. This 1.65 kilometer reduction in distance masks wide heterogeneity across and within the cities. The average distance fell by over 7 kilometers for the average Atlanta tract between 1980 and 1990 while it fell by only 0.18 kilometers in Boston and less than 0.15 kilometers in Chicago. The greatest within city transit access convergence took place in Atlanta and Portland relative to Boston, Washington or Chicago because the former cities started off with no transit network, so that almost every census tract saw an increase in access, whereas very few tracts saw access improvements in Chicago or Boston.

Such transit improvements have differential effects on census tracts within a given metropolitan area. Some census tracts experienced significant increases in transit access while other tracts did not. This latter set of census tracts provide a useful "control group" for inferring the counter-factual of what transit use changes would have been had

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[9] Now that the initial portion of Portland's MAX light rail line has been declared a success by transit advocates in Portland, the line is being extended through the western suburbs, eventually to the airport. Washington and Atlanta planned their systems more as a unit to be built at once, whereas Portland is working incrementally because of cost constraints and some community opposition.

[10] In the data section, we fully explain how we create each census tract's distance from transit.

access not increased between 1980 and 1990.

Improved light rail service may lead to reduced bus coverage in cities. Bus lines are often reoriented in new rail cities from serving the CBD directly to serving as feeders to rail lines. In this case, transit upgrades may be transit “downgrades” for bus commuters. The effect on bus service of new rail lines, though significant, is not huge, and new rail service did not decrease any of these transit systems’ geographic coverage. The number of buses used in peak periods and the expenditure on bus service only dropped approximately 10% in the five case cities during the 1980's (see Table Two). In 1990, the average distance of tracts to any bus line was 0.6 km, while it was 2.7 km to a bus that ran directly to the center city. These numbers rise to 1.1 km and 4.4 km respectively for those tracts farther than 2 km from a rail line in 1990. These figures show that even after rail was introduced, reasonable access to bus service, even direct bus service to the CBD, was for the most part still available.

III. New Transit’s Impact on Usage

An individual chooses her commuting mode based on travel time, costs incurred during the commute such as fares, tolls and the cost of parking. The transit access improvements listed in Table One could generate changes in commuter behavior under several scenarios. Someone who initially drives to work and is too far away from transit to walk is the most likely non-transit user that could potentially be convinced to switch modes. Either a transit line is built within a reasonable walking distance from the individual's residence, "kiss and ride" becomes viable, or it becomes easier to drive to a nearby transit station to "park and ride". This third scenario has probably been most targeted by transit planners in the near past.

We define potential walk and riders to be those individuals who live within two kilometers of a transit line. Between 1980 and 1990, transit upgrades led to over two million more households living within two kilometers of transit in our five case cities combined. How large could this incentive be? Suppose that a walker is now two kilometers closer to transit. Walking three miles an hour, this commuter saves 30 minutes a day or 125 hours per year. At a wage of $15 an hour, the time price of public commuting has just fallen by $625, assuming a conservative time-cost of commuting estimate of 33% of the hourly wage. For "park and riders" there is a much smaller effect which we calculate to be roughly $100.[11] Since the commuter drives to the public transit station, reductions in distance between one's residence and the public transit station do not have as great an impact on time savings.[12]

To study whether transit improvements stimulate usage, we present regressions in which the unit of observation is the census tract. Using 1980 and 1990 census tract data (described in the next section), we estimate a multivariate regression of the percent of

[11]See Waters (1995) for a discussion of various estimates of the time-cost of commuting.

[12]Lack of parking at places of employment and transit stations will affect transit ridership. Arnott and MacKinnon (1977) present a general equilibrium model of how locational choice and commuting patterns are affected by changes in parking. Merriman (1998) demonstrates that lack of parking at Chicago commuter rail stations limits ridership, and that ridership increases when parking is expanded. For park and riders, who make up a considerable percentage of potential new transit riders, transit station parking availability will affect behavior.

commuters who use public transit to get to work as a function of tract demographic variables and the tract's distance from public transit. This levels regression for tract I in city j at time t is presented in equation (1).

$$Public\ Transit\ Use_{ijt} = city\ fixed\ effects_{t} + \psi_{t} * CC_{ijt} + B\ X_{ijt} + \gamma\ Distance_{ijt} + U_{ijt} \qquad \textbf{(1)}$$

Controlling for tract average demographics (X) such as income, race, and education of the tract residents, city fixed effects and a central city dummy (CC), this regression's results yield an estimate of the propensity to use public transit as tracts' distance from transit changes. Distance proxies for the time cost of using public transit. There are two reasons why γ in equation (1) could be negative. First, greater distance raises the time cost of using public transit and this increase in the full price will reduce usage. Second, we might expect to find a negative γ due to population Tiebout sorting. Those households who plan to use public transit are more likely to choose to live next to transit. Since households are not randomly assigned across neighborhoods, observing that those who live close to transit use it more may not provide a reliable estimate of how the typical commuter's behavior would change if public transit became more accessible. In equation (1), the cross-sectional error term (reflecting unobserved average tract commuter taste for public transit) is likely to be correlated with distance from transit.

A straightforward approach for addressing this problem is to first difference the equation over time. For the five cities in our study, we observe all census tracts within 25 kilometers of the CBD in 1980 and 1990. From census data, we have constructed the change over the decade in the percentage of workers in each tract who commute using public transit. As presented in equation (2), we regress the census tract change in the percent of commuters using public transit on the change in distance to public transit, and the change in tract demographic characteristics.

$$\Delta\ Public\ Transit\ Use_{ijt} = city\ fixed\ effects + \psi * CC_{ijt} + B\ \Delta X_{ijt} + \gamma(\Delta\ Distance_{ijt}) + \Delta U_{ijt} \qquad \textbf{(2)}$$

Since we have multiple observations for each city per year (because our unit of analysis is the census tract), we estimate city-specific intercepts. These fixed effects control for changes in a city's transit fares, citywide changes in transit quality such as train speed, and changes in local economic conditions such as a decline in the CBD's share of jobs. Our controls for the change in the census tracts' demographic composition is represented by the X vector.

Our focus in estimating equation (2) is to test the hypothesis that increased access increases usage, or that γ is negative. We estimate equation (2) using GLS. This model's identifying assumption is that $E(\Delta U \mid \Delta \text{ Distance}, \Delta \text{ X}) = 0$. If the largest reduction in distance to transit has occurred in tracts where there has been a large unobserved increase in the census tract residents' taste for transit, then our estimates would overestimate the impact of increased transit access on an average tract's change in transit usage. The only way that a tract's average taste for transit usage to change would be due to a change in tract composition. We might expect tracts that end up close to transit to have an immigration of transit lovers, resulting in an unobserved increase in the tract's taste for transit use. Thus, for a given tract, γ can be interpreted as predicting the change in total propensity to use transit due to a change in transit access, not holding tract composition constant. Later we will discuss how we garner a cleaner estimate of the change in tract incumbents' ridership in response to new transit.

In section VII, we discuss for each of the cities why the transit improvement took place. While there are "winners" and "losers" from increased access in these cities, we believe that the transit improvements were exogenous to transit usage, and not triggered by local boosterism.

The economic intuition behind why estimates of equation (2) yield insights about commuter behavioral change is presented in Table Three. We show the 1980 to 1990 change in commuting time for two identical commuters who only differ because one lives in a tract whose access to transit increased between 1980 and 1990 and the other lives in a tract whose distance to transit did not change. Note that for both commuters, the overall quality of the service (including) the fare can change over the decade. Table Three displays a "difference in difference" calculation showing the commuting time saved for "walk and riders" and "park and riders".

There are three reasons why a census tract's average public transit usage for working commuters could rise between 1980 and 1990. First, greater access leads incumbent tract residents to change their behavior and substitute public for private transit modes. Second, greater access leads people who were out the labor force in 1980 and lived in the tract to enter the labor force and to commute by public transit. Third, transit improvements lead to selective migration such that the new migrants to newly served census tracts may be more inclined to use mass transit than the households who exit the tract.[13] Policy makers are likely to care most about the first and second effects.

Assuming that the population is immobile, γ provides a clean and full estimate of the change in transit usage that directly results from transit access improvements. Any change in incumbent behavior due to unobserved fixed effects drops out by first differencing, and we assume that all other change in incumbent ridership behavior is orthogonal to the change in transit access.

To deal with the potential migrant-incumbent transit taste differential, we adopt the following model. In making their location decisions, migrants choose to live either near or far from transit, depending on their taste for transit use. Their location choice is thus independent of the change in transit distance, and instead depends on the final level of transit distance. As long as migrants have the full capacity to Tiebout sort themselves into a location pattern commensurate with their taste for transit, we can control for their component of the change in transit use in response to new transit by adding the final level of transit access into equation (2). If, however, perfect Tiebout sorting is impeded through congestion or cost, then there may still be some indirect causal relationship between the change in transit distance and migrant transit use. We can control for these things by including the 1990 level of housing values, and the percent of each tract that has lived there for 5 years or less.[14]

We estimate the effect that migrants have on transit usage by inserting 1990

[13]The effect of incumbent residents entering the work force because of the availability of new transit has been found to be negligible (Baum-Snow 1998).

[14]If included, the coefficients on housing values and population turnover are not significant, so they are excluded.

distance to transit into equation (2). Migrants who are transit lovers will move to tracts that have good transit access. They do not make their location decision based upon a change in access, but instead it is based upon the final level of transit access. This addition yields equation (3).

$$\Delta\ Public\ Transit\ Use_{ijt} = city\ fixed\ effects + \psi * CC_{ijt} + B\ \Delta X_{ijt} + \eta(\Delta\ Distance_{ijt}) + \phi(Distance^{90}_{ijt}) + \Delta U_{ijt} \qquad \textbf{(3)}$$

Because incumbents respond only to the change in access, and migrants respond only to the level of access, η from equation (3) cleanly predicts the *treatment effect* of transit on usage. We can back out the *composition effect* by knowing the total effect from equation (2). The treatment effect will be a lower bound on the actual number of new transit riders for a tract, because we do not know the share of migrants who were riders in their old location. It thus follows that the total effect, from equation (2), is an upper bound on the total number of new transit riders for a given tract.

IV. Which Demographic Groups Gain From New Transit?

Transit improvements may not equally improve the quality of life of all demographic groups. Demographic groups may differ in their propensity to begin to use public transit. For example, younger workers who have not established commuting habits may be more environmentally conscious and more willing to use transit. Also, the transit improvements are not uniformly spatially distributed. Given that minorities are concentrated in central cities, and the wealthy are in the suburbs, it is important to test whether increased public transit is a regressive or progressive public policy (Massey and Denton 1993, Cutler, Glaeser and Vigdor 1998, Mieskowski and Mills 1993). Are the rich disproportionately served by new rapid transit service? Aggregate time series transport studies cannot address this issue.

The 1980 and 1990 Census micro data samples allow us to study differential trends in usage by demographic group. Unfortunately, the 1980 and 1990 micro samples do not provide census tract identifiers. Thus, we cannot study trends in use by various demographic groups as a function of the change in transit access. Instead, we present evidence on which demographic groups have significantly increased their public transit use in each city.

For each of the five metropolitan areas in 1980 and 1990, we present logit models of whether a working head of household uses public transit. We use the logit estimates to study changes in commuting patterns for specific demographic groups such as the young, the poor and the highly educated. We use the logit specifications to predict transit use in 1980. We then estimate coefficients for 1990, but predict public transit use in 1990 using the 1980 demographic means. Equation (4) presents the logit equation we use to predict a head of household's probability of using public transit in 1990.

$$prob(use\ city\ j's\ public\ transit) = \exp(B_{j,90}X_{80})/(1 + \exp(B_{j,90}X_{80})) \tag{4}$$

This approach allows us to study how transit usage probabilities have changed while fixing population demographics at their mean 1980 levels.

In addition to studying which demographic groups have substituted toward commuting using public transit between 1980 and 1990, we also examine which demographic groups are over represented in census tracts which are now closer to transit. To study who gains from transit improvements, we regress the percent change in transit access on census tract demographic attributes in 1980. We test the hypothesis that the reductions in distance are not randomly distributed to serve all demographic groups equally. Estimates from equation (5) provides evidence on which demographic groups are over-represented in increased access areas.

$$\Delta\ Distance_{ijt} = city\ fixed\ effects + \psi * CC_{ijt} + B\ X^{80}_{ijt} + V_{ijt} \tag{5}$$

The final hypothesis of interest is to test whether increased access is positively capitalized into housing values. Positive capitalization would be evidence that transit upgrades are amenities. It is possible that transit could be negatively capitalized into real estate prices because it increases negative externalities such as noise and crime. To test this, equation (6) presents the simple hedonic regression we estimate based on the change in real rents and home prices between 1980 and 1990.

$$\Delta\ home\ price_{ijt} = city\ fixed\ effects + \psi * CC_{ijt} + B\ \Delta X_{ijt} + \phi\ (\Delta\ Distance_{ijt}) + \Delta U_{ijt} \tag{6}$$

Estimating the regression in equation (6) provides new capitalization estimates and offers a cross check to study whether "distance matters".

V. Data Sets

This paper uses 1980 and 1990 Census of Population and Housing tract level data and micro data from the 1% PUMS. Tract-level data for 1980 and 1990 are taken from the Census of Population and Housing file stf3a. The spatial component was built using digital maps of census tracts and transit lines. The spatial coverages, or digital maps, of the transit system for each of the five cities were taken from the national Transit coverage of the 1996 National Transportation Atlas Database CD-ROM. It is approximately at the 1:100,000 scale. This means that the maps the digitized data was scanned in from had 1 mm represent 100 m. The census tract coverages came from the Census Tiger Database. Tracts for each of the counties included in the five MSAs were extracted separately and merged together to form one coverage for each MSA. The tract centroids were calculated using a script that comes as part of the Arcview software package.

The transit coverages for 1980 and 1990 were constructed using separate transit histories taken from various places off of the World Wide Web for each of the five transit systems studied.[15] Those cities without systems in 1980 (Portland and Atlanta) had transit access measured from the center of downtown. This was a point that was chosen based on the central business district, and was near to what was to be in 1990 the central portion of the transit system. The transit access variables, built using Arcview, were merged into the 1990 data set (because this is the year for which the Arcview census tract codes matched) and then converted back to 1980 tracts with the rest of the 1990 data using

[15] Details are available upon request.

population weighted conversion factors. This procedure yields a variable representing the distance to the nearest transit line. Thus, we assume that given the existence of a transit line, surrounding residential communities are given adequate access to this line through stations.[16]

In addition to the census tract level data, 1980 and 1990 1% Public Use Microdata Samples (PUMS) data are used to estimate a head of household's propensity to use mass transit. Using the 1980 and 1990 Census micro data, we construct a sample of working heads of household ages twenty and up. Public transport is coded as a dummy which equals one if person reports to commute by bus or trolley bus, streetcar or trolley car, subway or elevated, railroad or ferryboat.[17] Additional variables used include dummy variables for sex, race, age, living in the central city and a quadratic of household income. All demographic summary statistics are available on request.[18]

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[16]This is not an unfair assumption, for any reasonable planner will ensure that transit lines serve the maximum number of people possible along them. In Atlanta, the correlation between tract distance to transit line and transit station in 1990 is 0.9578.

[17]We use the percent of the population using all types of transit (rather than just rail riders) as the regressor because we want to pick up how many new total transit riders there are, not just those who switch to rail.

[18]The 1990 Census micro data is also used to study public transit use for households who have switched homes over the last five years. This estimate is needed to construct equation (3). We use the 1990 Census' geographical PUMA identifier to merge an aggregate measure of distance from transit for each PUMA. In most cases, PUMA boundaries were defined for the Census by state governments. While PUMAs generally are aggregations of census tracts and urban places, they do not reflect the boundaries of political jurisdictions. PUMAs are intended to reflect "like" areas containing 100,000 people or more.

VI. Results

Better Access to Transit Encourages More Use

Each column of Table Four reports a separate census tract regression. The left two columns report 1980 and 1990 cross-sectional regressions where the dependent variable is the level of public transit use (based one equation 1). Controlling for a host of demographics, city fixed effects, and a central city dummy, we find evidence of a negative statistically significant effect that increased distance decreases public transit usage. In 1980, an increase in transit access from the mean of 4.76 kilometers away to 3.76 kilometers away increases tract commuting by public transit by 21%. This translates into a total usage increase of 0.63 percentage points. The effect is roughly the same size in 1990.

Columns 3 to 5 of Table Four present three specifications of the 1980 to 1990 first differenced regression presented in equation (2). In estimating equation (2), we are testing whether γ is statistically significant and negative. If so, this would indicate that as a tract's distance to transit increases, public transit use falls.[19] These columns present change regressions where in one specification we include the log of distance and in the other specification we include a quadratic in distance. Columns 3 and 4 show that in a first difference specification, γ is negative and statistically significant but its coefficient is

[19]Tracts which were very close to transit in 1980 are likely to feature high transit usage in 1980 and in 1990. Thus, in a change regression the growth in transit usage in such tracts will be low and the growth in access will also be low.

not as negative as either the 1980 or 1990 levels specifications. Column 6 represents the regression listed in equation (3). It shows that the treatment effect of transit on usage is negative and statistically significant.

The key finding from Table Four is that based on the quadratic specification, the net result of moving a tract from 3 km to 1 km away from transit increases average tract transit usage by 1.4 percentage points. Median regression estimates of equation (2) yield similar significant coefficients to the standard GLS regressions reported in Table Four. [20] Of this 1.4 percentage points, 1.28 percentage points are due to the treatment effect on tract incumbents.

Figure One presents isoquants representing the set of 1990 transit distances for each 1980 distance that would be needed to achieve various total increases in transit use. The graph in Figure One is calculated using the coefficients on the change in quadratic distance reported in Table Four. Figure One is based on the thought experiment of taking a tract with a given transit distance, and moving it enough closer to transit to achieve a certain percentage point increase in total usage.

The lower graph in Figure One shows the treatment effect of new transit on incumbent use. For each total change in transit use, it depicts the treatment effect for each 1980 distance to transit, which is in turn paired with a unique 1990 transit distance in the

[20] To explore evidence of differential effects across the five cities, we have interacted the log distance to transit with city dummies. Washington, being the one city where transit use actually increased over the decade, is the only city for which the interaction coefficient is significant. Washington is fairly unique in that it is the only one of the five cities to be in the process of building its comprehensive transit system in 1980 (though there was a 3-year break between 1978 and 1981).

upper graph. The graph shows that the treatment effect makes up the bulk of the total effect. Note that at very large initial distances, the treatment effect is predicted to be greater than the total effect. This is not unlikely, given that these tracts are likely to lose transit lovers and attract those indifferent to the availability of transit service. Large increases in incumbent transit ridership make up this differential.

Table Five shows predictions of the number of new transit riders in each city, in response only to rail transit access improvements. We predict total and treatment effects, with the idea (explained in the methodology section) that the total effect is an upper bound and the treatment effect is a lower bound on total new ridership. They are estimated using the coefficients on the change in transit distance from equations (2) and (3) respectively. Average transit distance is constructed for each city in 1980 and 1990 by taking a weighted average of individual tract distances, weighted by 1980 population. The predicted increase in transit usage is then multiplied by the sum of the 1980 tract populations to yield the predicted number of new riders. The same procedure is used to calculate the predicted number of new walk and riders, except that only walk and ride tracts are included in the sample. It is important to note that these predictions assume no change in city wide demographics over the decade.[21] These predictions could be very different from actual changes in use if between 1980 and 1990 there have been changes in tract level demographics or structural changes in the city, that come out in the coefficients on the controls in equation (2).

[21]Walk and ride tracts are defined to be those greater than 2 km away in 1980 and fewer than 2 km away in 1990. Potential new walk and riders is defined to be the sum of the 1980 population in all such tracts.

The total number of predicted new transit users listed in Table Five is derived using equation (2), under the assumption that the only change in each city between 1980 and 1990 is the average tract distance from transit. Atlanta has by far the most predicted new transit users at 73,589, though this greatly overestimates actual transit ridership changes in Atlanta due to demographic shifts and structural effects unique to the city. In reality, Washington experienced the greatest growth in ridership, near the predicted 48,650 new riders.

About half of new transit usage is predicted to come from new walk and riders. We calculate that the number of new walk and riders given the 1980 spatial distribution of census tracts around transit lines would be 74,637 in the five case cities combined. Not surprisingly, the three cities with large-scale transit improvements (Atlanta, Washington and Portland) also have the greatest number of predicted new walk and riders due to their transit improvements.

Our estimates are quite comparable to earlier work. A literature has studied how sensitive public transit demand is to changes in fares, commuting times, spatial coverage and various other relevant measures. Kain and Liu (1995) report a fare elasticity of -0.34 based on 1980 to 1990 changes in transit ridership for 75 large transit operators.[22] Lago et. al (1981) present a summary of various studies estimating elasticities of demand. They report an elasticity of -0.47 for headways (time between vehicle arrivals at a stop), 0.72 for vehicle miles of center city transit routes, and -0.55 for travel time by transit based on

[22]This estimate matches the price elasticity measured to be about -0.33 as reported by Beesley & Kemp (1970).

studies of various American cities. Voith (1991,1993) creates a station level panel data set to study Philadelphia rail use. He finds fare price elasticities roughly comparable to earlier work and that rail riders are responsive to reduced commuting times. For example, an increase in train speed from 24 to 30 miles per hour increases ridership by 5.3% in the long run.

Transit Use and Transit Access by Demographic Group

Micro data allow us to study which demographics groups have increased their use of public transit. Tables Six and Seven present logit estimates of whether a head of household uses public transit to commute to work for each of the five cities. The specifications control for age, occupation, race, income, sex, marital status, education, and a central city dummy. The coefficient estimates in Tables Six and Seven are used to predict public transit use in each city, in 1980 and 1990 for different demographic groups.

Predicted probabilities of public transit use, by demographic group, are presented in Table Eight . In all the cities together, the poor reduced transit use from 24.6% to 18% between 1980 and 1990. With the exception of Portland, the poor are quitting transit faster than average. In Boston even though overall predicted use has fallen, college graduates and the young increased their likelihood of using public transit. Based on equation (4), we predict that the average head of household age 22-34 in Boston increased his probability of using public transit from 13.8% in 1980 to 15.9% by 1990. The average college graduate commuter’s probability of using public transit in Boston increased from

13.7% to 14.7% between 1980 and 1990.

The estimates in Table Eight are not directly comparable to those in Table Five. Table Five studies how transit use changes as a tract's distance to transit changes while holding all other factors constant. In Table Eight, we explore how the probability of public transit use for a worker, with a fixed set of demographic characteristics, changes between 1980 and 1990. One's probability of using public transit could change because access has changed or because jobs have suburbanized.

Given that each census tract is not a microcosm of the city's population, improvements in transit will have differential impacts on the population. Table Nine uses the census tract panel data set to identify the major beneficiaries of transit improvements. We present regressions of the propensity for new rail transit to serve the young, blacks, homeowners, and the wealthy, along with a multivariate regression including all of these demographic groups. Table Nine's results indicate that blacks and the young were not served by transit expansions, probably because of the tendency for expansions to be in suburban, or outer-center city areas. A tract with 10% more blacks in 1980 ended up 2.8% further from transit in 1990, relative to a tract with 10% more non-blacks. Similarly, a tract with 10% more people aged 22-34 ended up on average 4.13% further from transit in 1990, relative to a tract with 10% more middle-aged and older people.

Transit Upgrades are Capitalized into Real Estate Prices

Evidence from hedonic capitalization regressions confirm that transit is an amenity. Based on the change regressions (see equation 6) reported in Table Ten, a 1% decrease in transit distance increases rents by 0.024 percent and housing values by 0.034 percent.[23] While these estimates are statistically significant and positive, they are quite small. A tract which was 4 kilometers away from transit in 1980 which in 1990 is 2 kilometers away would experience an increase in median home prices of 1.5%. Our calculations suggest that a "walk and rider" living in tract which is now closer to transit would save over $600 a year. Given that real estate prices in improved access tracts have not nearly increased as much, this suggests that renters who are "walk and riders" are major beneficiaries of new transit. They save commuting time and their rents have not increased proportionately.

VII. Why Do We Keep Building New Rapid Transit?

New transit is costly to build and it appears to only have a small impact on commuter behavior. While some groups gain from transit improvements, our results are in accord with earlier studies which have concluded that aggregate consumer welfare is unlikely to be increased by improved transit.

Thus, the unresolved issue is: Why does transit continue to be built? Because of their greater flexibility and cost efficiency for low-density corridors, many have argued

[23] Past analysis of transit capitalization of housing prices have produced mixed results. Voith (1993) reports large rail access capitalization into Philadelphia's home prices. This capitalization grows as city employment rates grow. Gatzlaff and Smith (1989) find weak evidence that Miami home prices appreciated as a result of its Metrorail line. However, Cervero (1994) finds that transit is capitalized in office rents in Atlanta and Washington. Damm et al (1980) confirm that Washington property values went up in areas where Metrorail service was anticipated.

that expanding bus networks would have been a better way to spend the monies used for most recent rail transit improvement projects (Richmond 1998, Fauth & Gomez-Ibañez 1979)

Key to these expansion arguments, in light of rail transit's demonstrated inefficiency, is that the voters who pay the majority of the expansion costs are not usually the same ones that benefit the most from expansions. They are thus eager to take advantage of this highly subsidized good. Transit infrastructure, and to a lesser extent operation, usually amount to a large transfer from the state and federal governments for local gains, though this became less true during the 1980s. Local communities only paid for an average of 23.8% of transit expansions in 1990, and this percentage has been steadily rising, meaning that they have paid for even less of the expansions studied here.

Given the high subsidization of urban rail projects, local actors are rational in welcoming new rail projects. We have demonstrated that rail improves property values and gets a few people out of their cars, reducing congestion and improving the environment. In addition, there are benefits associated with prestige and providing the poor and disabled better access to the labor market. Though it is doubtful that the costs of building and maintaining new rail lines outweigh these benefits, expansions likely pass a cost-benefit analysis from the perspective of local communities.

Additional explanations for new transit construction are city-specific. Historically, inner-city areas have argued for better transit service in order to preserve access to jobs for those without cars. Recently, however, the building of new transit systems such as those in Portland and Atlanta has been motivated by other goals, such as urban renewal and environmental friendliness, in addition to the provision of better service to needy segments of the population. In its publication stating transit goals for the 21st century, the American Public Transit Association argues for denser urban development by arguing that "Efficient land use protects vulnerable environmental areas (and) results in decreased reliance on motorized vehicles, thereby reducing congestion and air pollution." (http://www.apta.com/pubs/online/m21rep.htm) This goes in tandem with luring suburbanites to use transit to get to work rather than driving. In addition, transit systems are often means of city boosterism. Some argue that an important reason Los Angeles has embarked upon its very expensive rail transit project in order to better position itself as a world-class city.[24] As with professional sports teams, there is a certain amount of prestige associated with having a rapid rail system that buses do not provide. Boston is perhaps the most interesting case city in that it had two very distinct changes during the 1980s, and that one of the changes involved the relocation of an existing rail route.[25] The extension of the Red Line, though it does run through areas that were poor, was built in order to serve commuters who could conveniently park their cars at the end of a major

[24] "I see subways in Paris, London, New York and other cities where the damn train is almost up to full speed before it exits the station," said LACTC alternate commissioner Roy Donley (http://the-tech.mit.edu/~richmond/professional/myth.pdf).

[25] In the 1980s, the Red Line was extended north from Harvard Square through a mixed income neighborhood in North Cambridge and Somerville to Alewife, which is primarily intended as a commuter stop for those living in the western suburbs, and is located conveniently at the end of a major highway. In addition, the dilapidated southern elevated portion of the Orange Line that ran above Washington Street was dismantled and moved to a depressed viaduct that also carries the Amtrak main train line to New York. The orange line viaduct runs along the northern fringe of the most impoverished areas of the city, whereas the former Washington Street Elevated ran right through the center of the ghetto.

artery running into the city. The relocation of the Orange Line was done because the elevated structure on which it ran was deteriorating badly. As in all of the other cities studied here, and the vast majority of cities in the country, the transit authority that oversees public transportation in the Boston area is a state agency, and thus independent of local governments in all of the areas it serves, though it receives funding from them as well as the state. Boston thus had the modest goals of maintaining the functionality of an old system and decreasing air pollution and congestion by making the subway more accessible to suburbanites.

Chicago's system is the most extensive of the five examined here. Chicago saw one major improvement and one small reduction in its urban rail system in the 1980s.[26] As in Boston, the Chicago Transit Authority is not a locally run agency. Chicago took advantage of public subsidies to connect its airport to the city by rail. More recently, Midway airport also has been connected to the Loop.

The first portion of Atlanta's MARTA rail system opened in 1979, and by 1988 the majority of the system was completed. One of MARTA's goal was expressly to serve poor people. The suburban stretches of the system were built where convenient, but the inner city portions were designed to serve poor areas. The building of MARTA is also interesting in that the bus system was forced to evolve as rail service replicated bus routes. In many outlying areas, rail transit was the first transit available, and feeder bus routes were established in tandem with rail. In effect, part of the idea behind MARTA was to

[26]The Jackson Park branch of the portion of the Green Line that serves the south side was shortened very slightly. In addition, the Blue Line was extended from Jefferson Park to O'Hare Airport in two stages in 1982 and 1983.

create a rail commuting culture from scratch.   MARTA is overseen by the state of Georgia, and like the other systems receives substantial support from the federal government, though a locally approved sales tax also supports transit in Atlanta.

The Metro in the Washington D.C. area was in the process of being constructed in 1980.   The Washington Metro was primarily intended as a commuting network, and notably the original sections of the network did not go through many poor areas, but were instead intended to connect from the suburbs to employment centers in the city and Arlington, Virginia. Over the course of the 1980s, the Green, Red and Orange Lines were extended significantly further into the Virginia and Maryland suburbs. Since 1990, the Green Line has been in the process of being expanded through poorer areas. Since the Washington Metro was built primarily using funding supplied by the federal government, there has been little possibility for local influence.

The building of the MAX light rail line in Portland, OR, for which the first installment opened in 1986, was intended to serve two purposes. The downtown portion, which runs street-level in traffic, was intended both to serve as the end of the commuter line and as a center of urban renewal and tourism. Historic trolleys run along this portion while modern Light Rail Vehicles (LRVs) run along the rest of the system, which runs from downtown to the eastern suburb of Gresham. Since 1990, the line has been in the process of being extended to the western suburbs as well. Tri-Met, which oversees all Portland area transit, receives state and local sales tax funding.

VIII. Conclusion

Exogenous growth in rail transit access brought about by transit improvements in five cities during the 1980s allows the opportunity to study the impact of urban rail transit upgrades on use, on the behavior of different demographic groups and on real estate values. Using geographical mapping software we created a unique data set of each census tract's change in access to transit, proxied for by distance. Merging this data to existing census data, we exploited within metropolitan area changes in distance to transit to provide new insights into the effects of urban rail transit upgrades. We find a small behavioral response of incumbent residents toward increased commuting by public transit, and a small capitalization of transit infrastructure into housing prices and rents. Given that transit improvements have been highly subsidized from non-local sources, it is not surprising that many local actors support these improvements.

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Table One

Public Transit Access Upgrades Between 1980 and 1990

	Census Tract Count		Average Transit Distance (km)		Average Share Using Transit to Get to Work	
	Total	New Walk & Ride	1980	1990	1980	1990
five city average	3586	514	4.76 (5.20)	3.11 (3.64)	0.23 (0.15)	0.22 (0.15)
Atlanta	411	234	8.64 (6.69)	2.26 (2.69)	0.21 (0.15)	0.18 (0.16)
Boston	488	18	3.32 (3.96)	3.14 (3.86)	0.22 (0.14)	0.21 (0.13)
Chicago	1252	16	2.46 (2.86)	2.33 (2.73)	0.30 (0.14)	0.28 (0.15)
Portland	322	81	8.76 (5.08)	5.26 (5.05)	0.13 (0.07)	0.10 (0.07)
Washington	1113	165	5.39 (5.16)	3.68 (3.91)	0.20 (0.15)	0.20 (0.14)

Notes: Values determined based on observations without missing values for any of the variables in the Table Four regressions. Standard deviations are listed below means.

Table Two

Trends in Bus Service

	Number of Buses During Maximum Service	
	1980	1989
Atlanta	658	566
Boston	842	839
Chicago	2121	1803
Portland	473	420
Washington	1545	1400
Source: National Urban Mass Transportation Statistics (1982, 1989)		

Table Three

The Change in Commuting Costs by Travel Mode in Locations With and Without Transit Upgrades

	Location A No Transit Improvement Between 1980 and 1990		Location B Transit Improvement Between 1980 and 1990	
	Drive to CBD	Walk and Ride	Drive to CBD	Walk and Ride
1980	D_A*W + $Park_{80}$	$(P_{A80} + T_{A80})$*W + F_{80}	D_B*W + $Park_{80}$	$(P_{B80} + T_{B80})$*W + F_{80}
1990	D_A*W + $Park_{90}$	$(P_{A80} + T_{A80})$*W + F_{90}	D_B*W + $Park_{90}$	$(P_{B90} + T_{B90})$*W + F_{90}
difference	$Park_{90}$-$Park_{80}$	F_{90}-F_{80}	$Park_{90}$-$Park_{80}$	$(P_{B90}-P_{B80})$*W + $(T_{B90}-T_{B80})$*W + F_{90} - F_{80}
Cost of Walk - Drive		$(F_{90} - F_{80})$ - $(Park_{90} - Park_{80})$		$(P_{B90}-P_{B80})$*W + $(T_{B90}-T_{B80})$*W + F_{90} - F_{80} - $(Park_{90}-Park_{80})$
Cost of Walk - Drive in tract B vs. tract A				$(P_{B90}-P_{B80})$*W + $(T_{B90}-T_{B80})$*W

Definitions: W = Wage*(time-value scaling factor), D_A = time cost for driving to CBD for resident of tract A and D_B = time cost for driving to CBD for resident of tract B. P_{A80} is the time cost of taking transit in 1980 from tract A and T_{A80} is the time cost of walking to transit in 1980 from tract A. P_{B80}, T_{B80}, P_{B90}, T_{B90} are similarly defined for tract B. F_{80} is the citywide fare for taking public transit in 1980 and F_{90} is the citywide fare for taking transit in 1990. $Park_{80}$ = the price of parking in the CBD in 1980 and $park_{90}$ is the price of parking in the CBD in 1990.

Table Four

How Rail Transit Upgrades Affect Use

Based on equations (1-3). Dependent variable is the share of tract commuters who use public transit. Unit of analysis is the census tract. Standard errors are listed under the coefficients.

	1980	1990	1980 to 1990 change			
specification	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0375 (0.0366)	0.1140 (0.0593)	-0.0069 (0.0051)	-0.0068 (0.0061)	-0.083 (0.0059)	0.0041 (0.0074)
log (Distance to Transit)	-0.0301 (0.0029)	-0.0273 (0.0025)				
Change in log (Distance to Transit)			-0.0195 (0.0035)	-0.0202 (0.0035)		
Change in Distance to Transit					-0.0081 (0.0014)	-0.0072 (0.0016)
Change in Distance to Transit Squared					0.0003 (0.0001)	0.0002 (0.0001)
1990 Distance To Transit						-0.0046 (0.0013)
1990 Distance to Transit Squared						0.0003 (0.0001)
Center City Dummy	0.1095 (0.0066)	0.0703 (0.0060)	-0.0182 (0.0052)	-0.0164 (0.0054)	-0.0159 (0.0052)	-0.0209 (0.0054)
Atlanta Dummy	-0.0606 (0.0111)	-0.1288 (0.0118)	-0.0386 (0.0111)	-0.0429 (0.0100)	-0.0357 (0.0118)	-0.0344 (0.0120)
Boston Dummy	-0.0070 (0.0079)	0.0179 (0.0090)	0.0003 (0.0060)	0.0099 (0.0063)	0.0094 (0.0062)	0.0085 (0.0063)
Portland Dummy	-0.0906 (0.0088)	-0.1222 (0.0085)	-0.0236 (0.0061)	-0.0124 (0.0069)	-0.0095 (0.0079)	-0.0054 (0.0088)
Washington Dummy	-0.0148 (0.0087)	0.0118 (0.0099)	0.0065 (0.0071)	0.0198 (0.0060)	0.0221 (0.0061)	0.0221 (0.0061)
Observations	3591	3662	3590	3586	3586	3586
Adjusted R-Squared	0.732	0.719	0.053	0.111	0.102	0.107

Additional controls not listed: quadratic of census tract household income, average tract education levels, tract percent female, percent college graduate, percent ages 20-35, 40-50, percent professional occupation, percent black. All of these coefficients are available on request. Each regression specification, with the exception of (3), includes these controls.

Table Five

Predicted New Transit Use

	1980 PMSA Pop. (,000s)	Predicted Total New Transit Users	Predicted New Incumbent Transit Users	Potential New Walk and Riders	Predicted Total New Walk & Riders	Predicted Incumbent New Walk and Riders
Atlanta	2,235	73,589	67,398	878,185	37,154	33,463
Boston	3,198	2,623	2,354	76,758	1,066	952
Chicago	7,460	7,921	7,090	82,065	2,142	1,918
Portland	1,336	25,610	23,603	336,572	15,409	13,926
Washington	3,475	48,650	43,857	642,809	18,866	16,902

Notes: Potential new walk and riders is calculated as the count of people who lived over 2 kilometers from rail transit in 1980 and fewer than 2 kilometers away from rail transit in 1990
The total predicted number of new walk and riders is based on the quadratic specification reported in Table Four applied only to new walk and ride tracts, holding all demographic variables constant at their 1980 levels.
The predicted number of new transit using incumbents are based on the coefficients on the change in distance from equation (3).

Table Six

1980 Public Transit Use Logit Estimates using Census Microdata

	Atlanta	Boston	Chicago	Portland	Washington D.C.
Professional Dummy	0.011 (0.150)	0.113 (0.091)	0.305 (0.054)	0.369 (0.170)	-0.010 (0.075)
Dummy for Ages 20-34	0.055 (0.156)	-0.215 (0.095)	-0.159 (0.054)	0.112 (0.180)	-0.048 (0.083)
Dummy for Ages 35-49	0.041 (0.166)	-0.255 (0.097)	-0.246 (0.055)	-0.103 (0.204)	-0.229 (0.086)
Black	0.839 (0.136)	0.626 (0.137)	0.181 (0.059)	0.266 (0.370)	0.403 (0.079)
Other	0.551 (0.550)	0.246 (0.224)	0.043 (0.092)	0.447 (0.349)	0.619 (0.162)
Household Income	-3.268 (0.717)	-1.530 (0.464)	-1.857 (0.260)	-1.305 (0.946)	-1.172 (0.383)
Household Income Squared	2.341 (0.576)	1.006 (0.362)	1.414 (0.195)	0.109 (0.878)	0.535 (0.293)
Female	0.700 (0.147)	0.547 (0.098)	0.439 (0.059)	0.925 (0.178)	0.343 (0.079)
Married	-0.403 (0.163)	-0.288 (0.100)	-0.388 (0.058)	-0.338 (0.187)	-0.491 (0.082)
Central City Dummy	1.272 (0.131)	0.949 (0.086)	1.091 (0.047)	0.917 (0.145)	1.122 (0.075)
College Graduate	0.250 (0.152)	0.405 (0.093)	0.629 (0.055)	0.325 (0.168)	0.543 (0.077)
Constant	-2.800 (0.241)	-1.779 (0.153)	-1.758 (0.093)	-2.742 (0.301)	-1.779 (0.139)
Observations	5401	6638	17338	2821	8681
Pseudo R-Squared	0.177	0.082	0.100	0.114	0.108

Notes: The dependent variable equals one if the worker commutes using public transit and zero otherwise. Standard errors are listed below coefficients. Summary statistics are available on request. Regressions are based on 1980 Census of Population and Housing 1% Sample micro data. The omitted category is a white male non-professional who is over age 49, not-married and lives in the suburbs and does not have a college degree.

Table Seven

1990 Public Transit Use Logit Estimates Using Census Microdata

	Atlanta	Boston	Chicago	Portland	Washington D.C.
Professional Dummy	-0.050 (0.176)	0.086 (0.094)	-0.015 (0.068)	0.202 (0.209)	0.085 (0.076)
Dummy for Ages 20-34	-0.081 (0.176)	0.175 (0.103)	0.245 (0.073)	-0.172 (0.233)	-0.090 (0.088)
Dummy for Ages 35-49	-0.019 (0.171)	-0.157 (0.102)	0.031 (0.070)	-0.071 (0.220)	-0.007 (0.080)
Black	1.619 (0.150)	0.591 (0.151)	0.442 (0.076)	0.624 (0.386)	0.665 (0.078)
Other	0.857 (0.349)	0.367 (0.159)	0.018 (0.089)	0.805 (0.278)	0.565 (0.111)
Household Income	-1.776 (0.503)	-0.340 (0.269)	0.003 (0.172)	-1.476 (0.594)	-0.777 (0.206)
Household Income Squared	0.408 (0.248)	0.004 (0.117)	0.056 (0.064)	0.389 (0.198)	0.172 (0.083)
Female	0.442 (0.154)	0.254 (0.095)	0.553 (0.070)	0.468 (0.203)	0.505 (0.076)
Married	-0.404 (0.169)	-0.487 (0.099)	-0.367 (0.071)	-0.639 (0.221)	-0.353 (0.080)
Central City Dummy	1.250 (0.141)	0.941 (0.091)	1.110 (0.060)	1.131 (0.187)	1.177 (0.068)
College Graduate	0.284 (0.168)	0.482 (0.097)	0.748 (0.069)	0.135 (0.210)	0.563 (0.080)
Constant	-3.509 (0.255)	-2.123 (0.143)	-2.723 (0.106)	-2.846 (0.313)	-2.403 (0.129)
Observations	6,645	6,295	11,612	2,582	9,534
Pseudo R-Squared	0.211	0.077	0.103	0.115	0.117

Notes: The dependent variable equals one if the worker commutes using public transit and zero otherwise. Standard errors are listed below coefficients. Summary statistics are available on request. Regressions are based on 1990 Census of Population and Housing 1% Sample micro data. The omitted category is a white male non-professional who is over age 49, not-married and lives in the suburbs and does not have a college degree.

Table Eight

Predicted Transit Use For Each Demographic Group

	Atlanta		Boston		Chicago	
Demographic group	1980	1990	1980	1990	1980	1990
all	.035	.024	.115	.113	.131	.116
ages 20-34	.044	.029	.138	.159	.145	.142
college graduate	.034	.022	.137	.147	.184	.170
non-college graduate	.036	.025	.104	.096	.116	.100
income <= 20	.111	.065	.209	.174	.246	.180
20<income <= 50	.038	.026	.121	.117	.143	.121
50 < income	.020	.011	.090	.086	.108	.094

The 1980 predicted probabilities are based on 1980 logit estimates for each city. To calculate the probability that a working head of household uses public transit we predict transit usage using the mean attributes from 1980. The 1990 predicted probabilities are based on equation (4) in the text. Household income is measured in $1,000s of 1990 dollars.

	Portland		Washington	
Demographic Group	1980	1990	1980	1990
all	.064	.037	.126	.104
ages 20-34	.081	.042	.152	.115
college graduate	.081	.040	.141	.119
non-college graduate	.058	.036	.117	.095
income <= 20	.131	.081	.241	.191
20<income <= 50	.066	.038	.147	.119
50 < income	.036	.022	.092	.076

The 1980 predicted probabilities are based on 1980 logit estimates for each city. To calculate the probability that a working head of household uses public transit we predict transit usage using the mean attributes from 1980. The 1990 predicted probabilities are based on equation (4) in the text. Household income is measured in $1,000s of 1990 dollars.

Table Nine

How Improved Transit Access Affects Different Demographic Groups

The dependent variable in each regression is the percent change in access to transit for the census tract between 1980 and 1990. See equation (5) in the text.						
specification	#1	#2	#3	#4	#5	#6
% homes occupied by owners	-0.106 (0.0807)					-0.0152 (0.128)
median income		-0.0098 (0.0577)				0.083 (0.071)
median income squared		-0.0013 (0.0061)				-0.003 (0.007)
% with more than 16 years of education			-0.219 (0.162)			-0.287 (0.225)
% of population ages 22-34				0.413 (0.200)		1.05 (0.363)
% black					0.283 (0.0740)	0.367 (0.079)
Central city dummy	0.111 (0.0690)	0.116 (0.0759)	0.127 (0.0647)	0.120 (0.0591)	0.0540 (0.0718)	0.057 (0.072)
Observations	3609	3630	3659	3602	3666	3659
Adjusted R-Sqrd	0.364	0.364	0.363	0.364	0.371	0.383
Note: Standard errors are in parentheses. The specification also includes city dummies. Unit of analysis is the census tract.						

Table Ten

Housing Capitalization of Transit

	log change in census tract median rental price 1980 to 1990		log change in census tract median home price 1980 to 1990	
	city dummies and central city dummy but no demographic controls	city dummies and central city dummy with demographic controls	city dummies and central city dummy but no demographic controls	city dummies and central city dummy with demographic controls
log change in distance to transit 1980 to 1990	-0.037 (0.014)	-0.024 (0.012)	-0.061 (0.034)	-0.034 (0.030)
Observations	3535	3410	3503	3371
Adj. R-Sqrd	0.418	0.348	0.536	0.500

Note: Standard errors are in parentheses. We suppress all regression coefficients on central city dummy, city dummies, median number of bedrooms, mean number of rooms, percent black, and quadratic median household income. The dependent variable in the change regressions is the percent change in rents or housing values. The regressions are based on equation (6) in the text.

Data Sources

1980 Census of Population and Housing, summary tape file 3a:

The files for The District of Columbia, Georgia, Illinois, Maryland, Massachusetts, Oregon and Virginia were downloaded from the Harvard-MIT Data Center. Census tract records for the Atlanta, Boston, Chicago, Portland and Washington MSAs were extracted from these files for building the variables of interest.

1990 Census of Population and Housing, summary tape file 3a:

This data was taken from a series of CD-ROMs from which Wessex software was used to extract tract-level data. Data for all of the counties that make up at least part of each of the relevant MSAs was extracted, from which the relevant variables were built.

MABLE Geographic Database

Relevant data extracted using the Mable/Geocorr version 2.5 Geographic Correspondence Engine (http://plue.sedac.ciesin.org/plue/geocorr.html)

National Transportation Atlas Databases 1996 CD-ROM, Transit File

TIGER Database of local boundaries

Transit Histories:

Chicago Transit Authority pamphlet in commemoration of CTA's 40th anniversary, 1987 (http://members.aol.com/chictafan/ctardate.html)
Atlanta's MARTA History (http://www.itsmarta.com/history.html)
125 of Portland's Transit History (http://www.tri-met.org/125years.htm)
Belcher, Jonathan. *Changes to Transit Service in the MBTA District 1964-Present*, 1996 (http://members.aol.com/netransit/private/mainarts.html)
Levey, Robert. *It Was 20 Years Ago . . .*, Washington Post, March 26, 1996